INFORMATION PROCESSING APPARATUS AND
INFORMATION PROCESSING METHOD

BACKGROUND OF THE INVENTION

5   Field of the Invention

The present invention relates to an information processing apparatus and a method therefor, and in particular to an information processing apparatus for using a 3D model (computer aided geometry model in

10   3D) generated by using 3D-CAD, and a method therefor.

Related Background Art

Conventionally, a CAD apparatus (especially, a 3D-CAD apparatus) is employed to design objects (hereinafter simply referred to as parts) having a

15   three-dimensional shape, such as parts for goods or products. Further, based on this design, metal molds for manufacturing parts are generated.

Before using the design information prepared by the CAD apparatus, attribution information, such as

20   dimensions, dimensional tolerances, geometric tolerances, annotations and symbols, are entered for a 3D model (3D geometry).

In order to enter this attribution information for the 3D model, planes, ridge lines, center lines

25   and vertexes of the 3D model are selected. For example, attribution information shown in Fig. 26 is entered for a 3D model shown in Fig. 24 (the front

view, the plan view and the side view of this 3D
model are shown in Fig. 25). The attribution
information includes:

distances (lengths, widths and thicknesses),
5 angles, hole diameters, radii, chamfering dimensions,
and dimensional tolerances accompanied by dimensions;

geometric tolerances and dimensional tolerances
to be added to planes and ridge lines, without
dimensions being entered;

10 annotations to be transmitted or instructed for
machining or manufacturing parts, units and products;
and

symbols that are determined in advance as a
premise for representing, for example, surface
15 roughness.

For adding attribution information to a 3D model,
roughly two methods, as follow, are employed.
(1) Method for adding dimensions, dimensional
tolerances, geometric tolerances, annotations and
20 symbols
* Dimension lines and projection lines are required
for the entry of dimensions and dimensional
tolerances.
* Leader lines are required for the entry of
25 geometric tolerances, annotations and symbols.
(2) Method for adding dimensional tolerances,
geometric tolerances, annotations and symbols without

dimensions being provided.

* Dimension lines and projection lines are not required.

* Leader lines are required for the entry of dimensional tolerances, geometric tolerances, annotations and symbols.

Further, a metal mold is produced by using a 3D model. In this case, an examination must be performed to determine whether a metal mold and a product for which the metal mold is used are obtained as designed.

The following problem has arisen with the conventional method for adding attribution information to the 3D model.

In case (1) described above, a dimension and a dimensional tolerance, and a dimension line and a projection line used to enter the dimension and the dimensional tolerance, become complicated, and it is difficult to see the geometry of a 3D model and the attribution information.

If, as is shown in Fig. 24, the 3D model has a comparatively simple shape and there are only several tens of attribution information sets, they can somehow be identified. However, since several hundreds or thousands, as needed, of attribution information sets are provided for a 3D model having a complicated or large shape, the reading of attribution information is extremely difficult

because "attribution information sets are overlapped", "attribution information is overlapped with the dimension line, the projection line or the leader line", or "the position of the dimension line, the

5   projection line or the leader line is not easily apprehended". It is rather difficult to see even the step-shaped corner shown in Fig. 26.

In the above case, since it is difficult for an operator to see attribution information that is input,

10   the operator can not confirm the contents of input information, i.e., the input of attribution information becomes difficult.

In addition, the reading of associated attribution information is also extremely difficult.

15   Further, since the space occupied by attribution information is increased for a 3D model, the geometry of the 3D model and the attribution information can not be seen at the same time on a display screen having a limited size.

20   Furthermore, for the attribution information (e.g., the depth of a 12±0.1 counter bore in Fig. 24) that is to be designated in the cross-sectional view, for example, the location whereat the attribution information is provided for the 3D model does not

25   appear and is hard to be understood.

In case (2), since the leader line is employed while the dimension line and the projection line are

not required, as in case (1), the leader lines are complicated and it is difficult to see the geometry of the 3D model and the attribution information. Further, since several hundreds to several thousands,

5 as needed, of attribution information sets are provided for a 3D model having a complicated or large shape, the reading of attribution information is extremely difficult.

In addition, the measurement of dimensions is

10 required in the process for examining a manufactured metal mold and a product obtained using the metal mold. Therefore, the operation using the measurement function for 3D geometry is required in order to read the dimensional values.

15 In this case, a portion that is used as a reference dimension must be selected to read a desired plane or ridge line. In order to read the dimensions of a plurality of portions, many operations and a long processing time are required.

20 Further, erroneous readings due to mistakes can not be avoided. Furthermore, an extremely large amount of labor is required to read the dimensions of all the portions.

Originally, a 3D model and attribution

25 information are data for the machining or manufacture of parts, units and products, and must be transmitted efficiently and accurately by a data input operator,

i.e., a designer, to a recipient operator, i.e., a machining, production or inspection engineer, so that the data can be easily understood. The conventional technique does not satisfy these requests, and is not
5   industrially effective.

It is, therefore, one object of the present invention to add attribution information to 3D data generated by a CAD apparatus, so that the information can be transmitted efficiently and accurately and can
10   therefore be easily understood. It is another object of the invention to add attributions to data to improve the operation.

It is an additional object of the invention to efficiently employ an attribution that is added.
15   It is a further objective of the invention to efficiently produce parts by utilizing data created by a CAD apparatus.

It is a still further object of the present invention to efficiently perform an inspection
20   process by using data created by a CAD apparatus.

SUMMARY OF THE INVENTION

Accordingly, one object of the present invention is to provide an information processing apparatus
25   comprising:

visual line setting means for setting an arbitrary visual direction for a 3D model;

attribution input means for entering attribution
information so as to position the attribution
information in the arbitrary visual direction set by
the setting means; and

5   storage means for storing the arbitrary visual
direction and the attribution information in
correlation with each other.

Another object of the present invention is to
provide an information processing method comprising:

10   a visual line setting step of setting an
arbitrary visual direction for a 3D model;

an attribution input step of entering
attribution information so as to position the
attribution information in the arbitrary visual

15 direction set at the setting step; and

a storage step of storing the arbitrary visual
direction and the attribution information in
correlation with each other.

A further object of the present invention is to

20 provide an information processing apparatus
comprising:

attribution input means for entering attribution
information for a 3D model;

attribution allocation plane setting means for

25 setting a virtual plane with which the attribution
information is correlated; and

storage means for storing the virtual plane and

the attribution information in correlation with each other.

Yet another object of the present invention is to provide an information processing method

5   comprising:

an attribution input step of entering attribution information for a 3D model;

an attribution allocation plane setting step of setting a virtual plane with which the attribution

10   information is correlated; and

a storage step of storing the virtual plane and the attribution information in correlation with each other.

Other features and advantages of the present

15   invention will become apparent during the course of the following description given in conjunction with the accompanying drawings, throughout which the reference characters provided for the figures thereof designate the same or similar parts.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flowchart showing the general processing for molded metal part mold production;

Fig. 2 is a block diagram showing a CAD

25   apparatus;

Fig. 3 is a flowchart showing the processing performed by the CAD apparatus in Fig. 2;

Fig. 4 is a diagram showing an example geometry model;

Fig. 5 is a conceptual diagram showing the correlation of individual sections constituting a geometry model;

Fig. 6 is a conceptual diagram showing a method used for storing Face information in an internal storage medium 201;

Fig. 7 is a plan view of a 3D model and an attribution allocation plane;

Fig. 8 is a diagram showing a 3D model and accompanying attribution information;

Fig. 9 is a diagram showing a 3D model and accompanying attribution information;

Figs. 10A and 10B are diagrams showing a 3D model and accompanying attribution information;

Figs. 11A and 11B are diagrams showing a 3D model and accompanying attribution information;

Fig. 12 is a flowchart showing the processing for adding attribution information to a 3D model;

Fig. 13 is a flowchart showing the processing for adding attribution information to a 3D model;

Fig. 14 is a flowchart showing the processing for adding attribution information to a 3D model;

Fig. 15 is a flowchart showing the processing for adding attribution information to a 3D model;

Fig. 16 is a flowchart showing the processing

for adding attribution information to a 3D model;

Fig. 17 is a flowchart showing the processing for setting a plurality of attribution allocation planes to a 3D model;

Figs. 18A and 18B are diagrams showing the state wherein a plurality of views are established for a 3D model;

Figs. 19A and 19B are diagrams of the 3D model viewed from an attribution allocation plane 214 in Figs. 18A and 18B;

Fig. 20 is a diagram showing the state wherein a 3D model and a plurality of attribution allocation planes are set;

Fig. 21 is a diagram of the 3D model viewed from an attribution allocation plane 215 in Fig. 20;

Fig. 22 is a diagram of the 3D model viewed from an attribution allocation plane 216 in Fig. 20;

Figs. 23A, 23B and 23C are diagrams showing the state wherein an attribution allocation plane is assigned for one part of a 3D model;

Fig. 24 is a diagram showing an example 3D model;

Fig. 25 is a front view, a plan view and a side view of the 3D model in Fig. 24;

Fig. 26 is a diagram showing the state wherein attribution information is provided for the 3D model in Fig. 24;

Fig. 27 is a diagram for explaining the state wherein icons are employed to display the contents viewed from the individual attribution allocation planes;

5   Figs. 28A, 28B, 28C and 28D are diagrams showing an example 3D model;

Figs. 29A, 29B, 29C, 29D and 29E are diagrams for explaining the state wherein a 3D model and attribution information are represented two-

10   dimensionally;

Fig. 30 is a flowchart showing the processing for setting a direction in which an attribution allocation plane is displayed;

Fig. 31 is a flowchart showing the processing

15   for displaying a 3D model using attribution information as a key;

Fig. 32 is a flowchart showing the processing for displaying a 3D model using geometry information as a key;

20   Fig. 33 is a diagram showing the state wherein a view is displayed in correlation with attribution information;

Figs. 34A and 34B are diagrams showing the state wherein attribution information is displayed in

25   correlation with an attribution allocation plane;

Figs. 35A and 35B are diagrams showing the state wherein attribution information is correlated with a

view;

Figs. 36A and 36B are diagrams showing the state wherein attribution information is correlated with an attribution allocation plane;

5   Fig. 37 is a flowchart showing the processing for generating a new view and for correlating attribution information with the new view;

Fig. 38 is a flowchart showing the processing for, when attribution information is generated,

10   automatically correlating attribution information with the view that is generated;

Fig. 39 is a flowchart showing the processing for changing one view to another view for the correlation of attribution information;

15   Fig. 40 is a flowchart showing the processing for employing another method to change one view into another view for correlation with attribution information;

Figs. 41A, 41B, 41C, 41D, 41E and 41F are

20   diagrams showing the processing in Fig. 39;

Figs. 42A, 42B, 42C and 42D are diagrams showing the processing in Fig. 40;

Fig. 43 is a flowchart showing the processing for correlating attribution information with a

25   plurality of attribution allocation planes and for correlating attribution information in the free state with one of the attribution allocation planes;

Fig. 44 is a diagram showing the state presented when attribution information is correlated with a plurality of views;

Fig. 45 is a diagram showing the state wherein
5   attribution information can be correlated not with only a view currently displayed on a screen, but also with another desired view;

Fig. 46 is a flowchart showing the processing for generating attribution information and for
10 correlation of the attribution information with an attribution allocation plane;

Fig. 47 is a diagram showing the state wherein attribution information is correlated with a plurality of attribution allocation planes;

15 Fig. 48 is a diagram showing the state wherein attribution information can also be correlated with an attribution allocation plane in the non-active state;

Fig. 49 is a flowchart showing the processing
20 for correlating generated attribution information with a desired attribution allocation plane at any time;

Fig. 50 is a flowchart showing the processing for changing or adding an attribution allocation
25 plane with which attribution information is correlated;

Figs. 51A, 51B, 51C, 51D and 51E are diagrams

showing the processing for changing or adding an attribution allocation plane for which attribution information is correlated;

Fig. 52 is a diagram showing a menu prepared to automatically correlate generated attribution information with a view that is set in advance; and

Fig. 53 is a diagram showing a menu prepared to automatically correlate generated attribution information with an attribution allocation plane that is set in advance.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

One embodiment of the present invention will now be described in detail while referring to the accompanying drawings.

General processing for metal mold production

Fig. 1 is a flowchart showing the general processing performed when the present invention is applied for the production of a metal mold for molded parts.

In Fig. 1, at step S101 a product is designed and design drawings for individual parts are prepared. The design drawings of the parts include required information for the production of parts and limitations. The design drawings of the parts are generated by a Computer Aided Design in 2 Dimension (2D-CAD) or a Computer Aided Design in 3 Dimension

(3D-CAD) system, and the drawing (3D drawing)
generated by the 3D-CAD system includes attribution
information such as geometric and dimensional
tolerances. The dimensional tolerances can be

5   correlated with the geometry (a plane, a ridge line,
a point), and is used to instruct the inspection of a
product and to instruct metal mold accuracy.

At step S102, the manufacturing, such as the
assembly or the molding of a product, is studied, and

10 a process drawing is generated for each part. The
process drawing for a part includes detailed
inspection instructions in addition to information
required for parts manufacture. A 2D-CAD or a 3D-CAD
system is employed to generate the process drawing

15 for the part.

Example inspection instructions are:

numbering of items to be measured (dimensions or
dimensional tolerances); and

an instruction for a measurement point or a

20 measurement method for an item to be measured.

At step S103, a metal mold is designed based on
the process drawing (a step drawing and a metal mold
specification) for the part prepared at step S102,
and a metal mold drawing is generated. The metal mold

25 drawing includes information required for metal mold
manufacture and a restriction condition. The metal
mold drawing is generated by a 2D-CAD or a 3D-CAD

system, and the metal mold drawing (3D drawing) generated by the 3D-CAD system includes attribution information, such as dimensions and dimensional tolerances.

At step S104 the process for the manufacture of the metal mold is studied based on the metal mold drawing generated at step S103, and a metal mold process drawing is generated. The metal mold manufacturing process includes NC machining and general machining. For the steps of the NC manufacturing (automatic machining using numerical control), an instruction for generating an NC program is issued. For the general machining (manual machining), an instruction for performing the general machining is issued.

At step S105, an NC program is generated based on the metal mold drawing.

At step S106, a machine is used to manufacture a metal mold part.

At step S107, the obtained metal mold part is inspected based on the information generated at step S103.

At step S108, metal mold parts are assembled >to form a mold.

At step S109, a part obtained by molding is inspected based on the information generated at steps S101 and S102. If the inspection results satisfy a

predetermined reference level (OK), the processing for producing a metal mold for a molded part is thereafter terminated.

When the inspection results do not satisfy the
5   predetermined level, at step S110, based on the inspection results at step S109, a metal mold is corrected for which the accuracy of the molded product is insufficient.

Product design

10   An explanation will now be given for the design of a product and the generation of a design drawing for each part. The design drawing for the part is generated using a 2D-CAD or a 3D-CAD system.

First, the design of a part will be explained by
15   using an information processing apparatus illustrated in Fig. 2, e.g., a CAD apparatus.

Fig. 2 is a block diagram of a CAD apparatus. In Fig. 2, an internal storage medium 201 and an external storage device 202 are semiconductor storage
20   devices or magnetic storage devices, such as RAMs, for storing CAD data and a CAD program.

A CPU device 203 controls the individual blocks of the CAD apparatus, and also performs the processing in accordance with a CAD program command.

25   A display device 204 is used to display various drawings (a 3D drawing and a 2D drawing), and buttons and instructions necessary for the operation.

An input device 205, such as a mouse or a keyboard, is used to provide an instruction for the CAD program.

An output device 206, such as a printer, outputs
5   a drawing sheet in accordance with a command received from the CPU device 203.

An external connecting device 207 connects the CAD apparatus to an external device, supplies data received from the CAD apparatus to an external device,
10   or permits an external device to control the CAD apparatus. Further, the external connecting device 207 is used to download, from an external device, a CAD program for the processing in this embodiment.

Fig. 3 is a flowchart showing the processing
15   performed by the CAD apparatus in Fig. 2.

First, when an operator uses the input device 205 to enter an instruction to activate the CAD program, the CAD program stored in the external storage device 202 is read into the internal storage
20   medium 201 and is executed by the CPU device 203 (step S301).

Then, in consequence with instructions interactively entered by the operator using the input device 205, a geometric model, which will be
25   described later, is generated in the internal storage medium 201 and is displayed as an image on the display device 204 (step S302). Further, when the

operator uses the input device 205 to designate a
file name, the previously prepared geometric model
stored in the external storage device 202 can be read
into the internal storage medium 201 where it can be

5   handled by the CAD program.

The operator employs the input device 205 to
generate, in a three-dimensional space wherein a
geometry model is prepared, an attribution allocation
plane constituting a virtual plan for which

10 attributions allocated or with which attributions are
correlated (step S303).

The attribution allocation plane is displayed as
image data, such as a frame (a double frame for which
the interior is painted with a solid color), so that

15 the location of the attribution allocation plane is
easily discerned. Further, information for setting
the attribution allocation plane is stored on the
internal storage device 201 in correlation with the
geometry model.

20 Furthermore, it is preferable that, as needed, a
name be provided for an attribution allocation plane
that is generated.

The operator employs the input device 205 to add
attribution information, such as a dimensional

25 tolerance, to the geometry model (step S304). The
added attribution information can be displayed as
image data (text, symbols, or labels) on the display

device 204, and also is stored on the internal storage deicer 201, in correlation with the geometry model.

The operator employs the input device 205 to
5   correlate the attribution information with the attribution allocation plane (step S305).

"Correlation" is implemented as follows. Unique identifiers are allocated for the attribution information, while unique identifiers are allocated
10   for the attribution allocation planes. The identifiers for the attribution information are correlated with those for the attribution allocation planes, and correlation information is generated between the attribution information and the
15   attribution allocation plane. In this manner, "correlation" is performed.

The correlation information between the attribution information and the attribution allocation plane is stored on the internal storage
20   medium 201.

The operator may designate an attribution allocation plane in advance, and may add attributions while correlating the attribution information with an attribution allocation plane. Further, the operator
25   can employ the input device 205 to set or cancel the correlation of the attribution information with the attribution allocation plane.

Then, the operator designates an attribution
allocation plane by using the input device 205, and
either controls the display/non-display of an
attribution allocation plane and attribution
5   information, such as a dimensional tolerance, that is
correlated with the attribution allocation plane, or
controls the coloring (step S306).

When the operator generates an attribution
allocation plane using the input device 205, the
10   operator sets display information (the visual
position, the visual direction and the magnification)
for an attribution allocation plane. When the display
information for the attribution allocation plane is
set and the attribution allocation plane is
15   designated, a geometry model can be displayed in
accordance with the designated visual position,
visual direction and magnification. Then, since the
attribution allocation plane and the attribution
information are correlated, the attribution
20   information correlated with the designated
attribution allocation plane can be selectively
displayed. The display information for the
attribution allocation plane is stored on the
internal storage medium 201.

25   In accordance with an operator's instruction,
the attribution information can also be stored in the
external storage device 202 (step S307).

The identifier can be added to the attribution information, and together with identifier, the attribution information can be stored in the external storage device 202.

5   This identifier is an attribution value that is added to the attribution information in order to distinguish it from other attribution information. When data concerning the attribution information are to be exchanged by a plurality of programs, unique

10   identifiers are added to the attribution information to permit the data concerning the attribution information to be handled in correlation with the attribution information.

As an example, when the measurement results

15   output by a measurement instrument are correlated with attribution information, such as a dimension, measurement results that are added to the dimension correspond to those added to the identifier. As a result, the measurement results can be read in

20   correlation with the dimension.

Further information can be added to the attribution information in the external storage device 202, and the resultant data can be read to the internal storage medium 201 to update the attribution

25   information.

Finally, the operator employs the input device 205 to store in the external storage device 202 a CAD

attribution model obtained by adding, to a geometry model, the position information for the attribution allocation plane, the display information for the attribution allocation plane and the attribution

5   information (step S308).

A geometry model and a CAD attribution model

The geometric model and the CAD attribution model will now be described.

Fig. 4 is a diagram showing an example geometric

10   model, and Fig. 5 is a conceptual diagram showing the correlation of the individual portions that constitute the geometric model.

In Fig. 4, SolidModel is shown as a typical example for the geometric model. As is shown in Fig.

15   4, the SolidModel information is used as an expression method whereby CAD is employed to define in a three-dimensional space the geometry of a part, which includes topological information (Topology) and geometric information (Geometry). As is shown in Fig.

20   5, the topological information for the SolidModel is hierarchically stored on the internal storage medium 201, and includes one or more than Shell, one or more than Face for one Shell, one or more than Loop for one Face, one or more than Edge for one Loop and two

25   Vertexes for Edge.

Further, Surface information that expresses the Face geometry, such as a flat plane or a cylindrical

plane, is stored on the internal storage medium 201
in correlation with the Face. Also, Curve information
that expresses Edge geometry, such as a linear line
or an arc, is stored on the internal storage medium

5   201 in correlation with the Edge. And in addition,
the coordinates in the three-dimension space are
stored on the internal storage medium 201 in
correlation with the Vertexes.

For the topological elements of the Shell, the

10 Face, the Loop and the Vertex, correlated attribution
information is stored on the internal storage medium
201.

As an example, the method for storing the Face
information on the internal storage medium 201 will

15 now be described.

Fig. 6 is a conceptual diagram showing the
method for storing the Face information on the
internal storage medium 201.

As is shown in Fig. 6, the Face information

20 includes a FaceID, a pointer to LoopList, which
constitutes the Face, a pointer to the Surface data,
which represents the Face geometry, and a pointer to
the attribution information.

LoopList is a list of the IDs of all the Loops

25 that constitute the Face. The Surface data includes
SurfaceType and SurfaceParameter, which is consonant
with SurfaceType. The attribution information

includes an attribution type and an attribution value consonant with the attribution type, and the attribution information includes a pointer to the Face and a pointer to a group to which an attribution

5 belongs.

Input and display of attribution information for a 3D model

(Attribution allocation plane)

A detailed explanation will now be given for the

10 processing for entering attribution information for a 3D model, for generating an attribution allocation plane, and for displaying a 3D model to which the attribution information is added.

Figs. 7 to 11 are diagrams showing a 3D model,

15 attribution information and an attribution allocation plane, and Figs. 12 to 14 are flowcharts for the processing for adding an attribution allocation plane and attribution information to a 3D model.

At step S121 in Fig. 12, a 3D model 1 in Fig. 7

20 is generated, and at step S122, a required attribution allocation plane is established.

The attribution allocation plane is used to define a condition concerning the display of the 3D model 1 and the attribution information added to the

25 3D model 1.

In this invention, the attribution allocation plane is defined by using the position of one point

(hereinafter referred to as a visual point) in (virtual) three-dimensional space and the normal direction (matching the visual direction) of a plane to be generated. Further, information for the display

5   magnification (hereinafter refereed to simply as a magnification) of the 3D model 1 and the attribution information added to the 3D model 1 is also included.

The visual point is used to define the position from which the 3D model 1 is seen, i.e., is displayed

10   in the visual direction. For example, an attribution allocation plane 212 is set at a position located 60 mm from the outline of a front view 201 of the 3D model 1 (Fig. 7).

It should be noted, however, that, as regards a

15   perspective view (a front view, a plan view, right and left side views, a bottom view and a rear view) presented by the so-called trigonometry, the display contents are not affected so long as the visual position is located outside the 3D model 1.

20   Further, when the 3D model 1 and the attribution information added to the 3D model are displayed, the visual position of the visual line corresponds to the center of the display of the display device 204, regardless of the preceding display state.

25   Then, the normal direction of the attribution plane corresponds to the visual direction, extended from the visual point, in which the 3D model 1 and

the attribution information added to the 3D model 1 are displayed.

Further, the magnification is defined as a magnification at which the 3D model in the (virtual) three-dimensional space is enlarged for display on the display device 204.

The visual position, the visual direction (the normal direction of the attribution allocation plane) and the magnification, which are parameters for the attribution allocation plane, are set as variables as needed.

For example, in Fig. 7, an attribution allocation plane 211 is determined that is perpendicular to a face 201a in the plan view in Fig. 25 and for which the direction from the outside to the inside of the 3D model matches the visual direction. The visual position and the magnification are determined so that the geometry of the 3D model 1, and substantially all the attribution information that is provided, can be displayed on the screen of the display device 204. For instance, in this embodiment, the magnification is "1", and a visual position 201f is defined substantially as the center of the face 201a in the plan view (a chained line 201d in Fig. 7 indicates the state wherein the contour of the front view is substantially projected onto the attribution allocation plane 211). Similarly,

an attribution allocation plane 212 is set in the
visual direction perpendicular to the face 201c in
the front view, and an attribution allocation plane
213 is set in the visual direction perpendicular to a
5 face 201b in the side view.

In order to clearly identify the positions of
the individual attribution allocation planes, these
planes are represented using square double frames. In
this embodiment, the frames are employed as means for
10 clearly indicating the position of the attribution
allocation information. However, the present
invention is not limited to the use of the square
double frames, and polygons other than squares, or
circles may be employed. The attribution allocation
15 plane 211 is positioned in parallel to an upper plane
201a of the 3D model 1, the attribution allocation
plane 212 is positioned in parallel to a front plane
201b of the 3D model 1, and the attribution
allocation plane 213 is positioned in parallel to a
20 side plane 201c of the 3D model 1.

(Method for entering attribution information)

Attribution information is entered in
correlation with each attribution allocation plane
set at step S123. At this time, the attribution
25 information is allocated on the attribution
allocation plane. Figs. 8, 10A and 11A are diagrams
showing the state wherein attribution information is

provided for a 3D model in correlation with the attribution allocation planes 211, 212 and 213. Figs. 9, 10B and 11B are diagrams showing the 3D model 1 and attribution information that are displayed at the

5   visual positions, in the visual directions and at the magnifications of the attribution allocation planes 211, 212 and 213.

    The size of attribution information (the height of a character or a symbol) correlated with the

10   attribution allocation plane is changed in accordance with the magnification used for the attribution allocation plane. The size (mm) of the attribution information is defined as the size in the virtual three-dimensional space wherein the 3D model is

15   present (not the size when the attribution information is displayed on the display device 204).

    The correlation of the attribution allocation plane and the attribution information may be performed after the attribution information is

20   entered. For example, a 3D model is prepared as in the flowchart in Fig. 13 (step S131), at step S132 attribution information is input, and at step S133 attribution information is correlated with a desired attribution allocation plane. Further, as needed,

25   corrections such as addition or deletion are performed for the attribution information correlated with the attribution allocation plane.

When the attribution information is correlated
with another attribution allocation plane, the size
of the attribution information is changed in
accordance with the magnification used for the
5   pertinent attribution allocation plane.

The attribution information may be entered while
the 3D model 1 is displayed two-dimensionally in the
visual direction defined by each attribution
allocation plane. This input process can be performed
10   in exactly the same manner as is performed at the
step for the creation of a two-dimensional drawing
using so-called 2D-CAD. Further, as needed, the
attribution information may be input while the 3D
model is displayed three-dimensionally. Since an
15   operator can input attribution information while
observing the 3D model 1 in three dimensions, an
efficient input process can be performed without any
errors.

An explanation will now be given for a case
20   wherein the attribution information for the 3D model
1 is read. At step S141 in Fig. 14, a desired
attribution allocation plane is selected. At step
S142, the geometry of the 3D model 1 and the
attribution information correlated with the
25   attribution allocation plane selected at step S141
are displayed, based on the visual position, the
visual direction and the magnification used for the

selected attribution allocation plane. For example, when the attribution allocation plane 211, 212 or 213 is selected, the 3D model 1 and the attribution information shown in Fig. 9, 10B or 11B are displayed,

5   so that regardless of the preceding display state, the attribution allocation plane is positioned in the normal direction of the screen. At this time, the attribution information is displayed in the visual direction of the selected attribution allocation

10   plane, i.e., is positioned normally on the screen. Thus, the 3D model and the attribution information on the display screen can be seen so that they can extremely easily be understood.

     (Method for selecting an attribution allocation

15   plane)

     An explanation will now be explained for a case wherein an attribution allocation plane can be easily selected. First, as one method (Fig. 7), the frame of the attribution allocation plane of a selectable 3D

20   model is displayed, and an operator employs the input device 205, including a pointing device such as a mouse, for the selection of the attribution allocation plane.

     As another method (not shown), the names of

25   selectable attribution allocation planes are displayed as a list for the selection of a desired attribution allocation plane.

As an additional method (Fig. 27), the attribution allocation plane (Fig. 9, 10B or 11B), as seen in the visual direction, is displayed as a thumbnail image icon and selected.

5   (Another method for entering attribution information)

In the attribution information entering processing described above while referring to Figs. 11 to 14, the attribution information is correlated

10   with the individual attribution allocation planes. The correlation means is not limited to this arrangement, however, and the attribution information may be sorted into groups, for example, and the groups correlated with the attribution allocation

15   planes.

This process will now be described while referring to the flowcharts in Figs. 15 and 16.

The attribution information input in advance either is sorted into groups selectively or is based

20   on the search results, and each group is correlated with an arbitrary attribution allocation plane. As a result, the same results and effects as described above can be obtained. Further, when the attribution information is corrected, i.e., is added to a group

25   or is deleted therefrom, attribution information correlated with the attribution allocation plane can be manipulated.

That is, the 3D model 1 is generated (step S151), the attribution information is entered (step S152), and the visual position and the visual direction of the attribution allocation plane, and the

5 magnification are set for the 3D model 1 (step S153). Then, the attribution information input at step S152 is assembled into a group, and the selected attribution allocation plane is correlated with the grouped attribution information (step S154).

10 As is shown in Fig. 16, the attribution allocation plane to be displayed is selected (step S161), and the attribution information correlated with the selected attribution allocation plane is displayed, while being positioned in accordance with

15 the visual point and the visual direction of the attribution allocation plane and the magnification (step S162).

(Setting up a plurality of attribution allocation planes)

20 An explanation will now be given for the processing for setting up a plurality of attribution allocation planes with the same visual direction orientation (these attribution allocation planes are set parallel to each other).

25 Fig. 17 is a flowchart for the processing for setting up a plurality of attribution allocation planes with the same visual direction orientation.

Fig. 18 is a diagram showing a 3D model when a plurality of attribution allocation planes with the same visual direction orientation are to be set up.

An explanation will be given for a case wherein
5   a plurality of attribution allocation planes are set up for which the perspective direction is that of the front view of the 3D model 1 in Fig. 7.

As is described above, the 3D model 1 is created (step S171), and at step S172, the attribution
10 allocation plane 212 (the visual position, the visual direction and the magnification), which is a first attribution allocation plane, is set. The visual direction of the attribution allocation plane 212 is perpendicular to the plane 201b in the front view,
15 the magnification is, for example, "1", and the visual point is located at a distance of 30 mm from the exterior surface of the front view, and is substantially in the center of the plane 201b of the front view.

20 At step S173, the attribution information in Fig. 10A is entered in correlation with the attribution allocation plane 212, so that, as is shown in Fig. 10B, the 3D model 1 and the attribution information can extremely easily be seen two-dimensionally in the
25 visual direction of the attribution allocation plane 212.

At step S174, the attribution allocation plane

(the visual position, the visual direction and the magnification) of the attribution allocation plane 214, which is the second attribution allocation plane, is set. The visual direction of the attribution

5   allocation plane 214 is set so it is parallel to the plane 201b in the front view, the magnification is set to "1", for example, and the visual position is set so that it includes the center axis of the hole in the 3D model.

10   The attribution allocation plane 214 is painted as a square shaped solid color. At this time, as is shown in Fig. 19B, the 3D model 1 viewed from the attribution allocation plane 214 is a cross-sectional view cut along the virtual plane 214. Then, the

15   attribution information (e.g., the size 12±0.1 of the hole in Fig. 19B) is input in correlation with the attribution allocation plane 214. Further, when the attribution allocation plane 214 is selected, the cross section of the 3D model 1 and the attribution

20   information correlated with the attribution allocation plane 214 are positioned and displayed as shown in Fig. 19B.

      When the 3D model is moved or rotated, the three-dimensional display as shown in Fig. 19B can be

25   obtained.

      Specifically, when the attribution allocation plane 214 is selected, the 3D model 1, which is

located in the visual direction of the attribution allocation plane 214, and the attribution information, which is correlated with the attribution allocation plane present in the area in the visual direction,

5   are displayed, and the 3D model geometry and the attribution in the area opposite from the visual direction (see Fig. 18B) are not displayed.

According to the embodiment, not only the attribution information related to the external

10 geometry, but also the attribution related to the cross-sectional shape in the same visual direction can be handled. Therefore, since the attribution information can be entered and displayed by referring to the cross-sectional shape, the portion indicated

15 by the attribution information can be easily and immediately identified.

In addition, a plurality of attribution allocation planes whereon the geometry of the 3D model 1 appears the same may be employed. Fig. 20 is

20 a diagram showing attribution allocation planes 215 and 216 having the same visual direction. In this example, the attribution allocation planes 215 and 126 are directed to the front view of the 3D model 1. When the attribution information is, for example,

25 grouped to be correlated with the individual attribution allocation planes, the attribution information can be more easily seen. For example, in

Fig. 21 for the plan view of the 3D model 1, the attribution information sets related to the external dimension are grouped.

Fig. 22 is a diagram showing attribution information groups concerning the position and the shape of the hole. The attribution information groups are correlated with the attribution allocation planes 215 and 216. Since the related attribution information is grouped and is allocated to the attribution allocation plane, the associated attribution information can be more easily seen.

(Location of attribution information)

In order to express a 3D model and attribution information to be added thereto so that they can be easily seen as a two-dimensional drawing, an operator selects or groups a plurality of attribution information for the portion of a 3D model to be expressed, and correlates the attribution information with the attribution allocation plane. So long as a two-dimensional drawing method is employed, the attribution information need only be allocated in an area in the visual direction of the correlated attribution allocation plane. However, for a so-called "3D drawing" where attribution information is added to a 3D model, some devices are required to satisfactorily demonstrate the merits of the 3D model.

One of the merits of the 3D model 1 is that,

since the 3D model 1 can be three-dimensionally
expressed on a display screen so its appearance is
near that of the real object, the process
(conventionally performed mainly in the mind of the
5   operator) for the transformation from two dimensions
to three dimensions, which is required for the
preparation of a two-dimensional drawing, is not
required for an operator who prepares a 3D model or
an operator (a step designer, a metal mold
10   designer/manufacturer, a measurer, etc.) who performs
the next step using the 3D model. This transformation
process depends greatly on the skill of the operator,
and accordingly, erroneous transformations and the
loss of transformation time occur.

15   In order to prevent the loss of the merit of the
3D model 1 represented by the three-dimensional
expression of a model in a 3D drawing, certain
devices are required for the three-dimensional
display of attribution information (the location of
20   attribution information).

        A point to be contrived will now be described
while referring to Figs. 28A to 28D.

        Fig. 28A is a perspective view of a 3D model 2
used for the explanation. Fig. 28B is a plan view of
25   the 3D model 2. Fig. 28C is a perspective view for
explaining the state wherein attribution information
is added to the 3D model 2 without an allocation

system being devised. Fig. 28D is a perspective view
of the attribution information for which an
allocation system has been devised.

First, an attribution allocation plane 218 is
5   prepared and attribution information is entered in
order to generate a two-dimensional plan view for the
3D model 2. The state wherein the 3D model 2 is
displayed along the visual line of the attribution
allocation plane 218 is shown in Fig. 28B.

10   When a plurality of attribution information
allocation planes are alternately arranged as is
shown in Fig. 28C in order to input attribution
information, the attribution information sets are
overlapped and it is difficult to identify the

15   contents of the attribution information. Since as in
Fig. 28C the contents of the attribution information
are not easily seen even when only a small number of
attributions is provided, it is easily assumed that,
for a more complicated geometry, the attribution

20   information will not be effective and that it will
not be possible to establish the perspective state as
a drawing.

However, when as is shown in Fig. 28D the
attribution information sets are allocated on the

25   same plane, the attribution information sets do not
overlap each other and can be easily identified, as
in the representation of the two-dimensional drawing

in Fig. 28B.

In this manner, when the attribution information is added to the 3D model, as in the two-dimensional representation, the attribution information can be
5   easily identified, while the merit of the 3D model, i.e., the three-dimensional representation, is employed. Thus, the obtained drawing can be used as a three-dimensional drawing.

Further, it is preferable that the plane whereon
10 attribution information is to be allocated be the same plane as the attribution allocation plane.

In this example, a simple 3D model has been employed; however, when a more complicated 3D model is handled, a plurality of attribution allocation
15 planes must be set in the same visual direction.

Assume that a plurality of attribution allocation planes and correlated attribution information are displayed together in order to select a desired attribution allocation plane or desired
20 attribution information.

In this case, if the face whereon the attribution information is allocated is at a distance from the attribution allocation plane, the correlation of the attribution information and the
25 attribution allocation plane is not easily perceived, and the attribution allocation plane or the attribution information may be erroneously selected.

In order to prevent such an erroneous selection and make it easy to visually perceive the correlation, the attribution information should be allocated on the same plane as the attribution allocation plane.

5   Further, to generate the attribution allocation plane in the same visual direction as explained while referring to Fig. 20, a plurality of attribution allocation planes should be allocated in the same visual direction. When the attribution allocation

10   planes and the correlated attribution information are displayed at the same time, and when the attribution allocation planes are generated on the same face, the face on which the attribution information is allocated is also on the same plane, the attribution

15   information sets are overlapped and not easily identified, not only in the visual direction, but also in an oblique direction shifted away from the visual direction. Originally, because a large number of attribution information sets are provided in one

20   direction, the attribution information sets are allocated for a plurality of attribution allocation planes, so that the overlapping of attribution information sets can not be avoided when they are displayed at the same time.

25   Even when no means is available to resolve the problem that attribution information can not easily be seen in the visual direction, arranging the

attribution allocation planes at a distance in the same visual direction is an effective means for easily identifying the attribution information in the perspective state.

5   (Magnification)

When the attribution allocation plane is displayed at a desired magnification, a complicated or a detailed shape can more easily be seen.

Figs. 23A to 23C are diagrams showing the state

10 wherein the 3D model 1 is partially enlarged and displayed. As is shown in Fig. 23A, while the visual direction of the 3D model 1 is oriented toward the plan view, the visual line position is set near the corner and the magnification is set to 5, the

15 attribution allocation plane 217 is provided for the 3D model 1, and the step-shape and the attribution information can be displayed so they are easily understood (Fig. 23B).

This embodiment is effective for all 3D-CAD and

20 2D-CAD systems, regardless of the hardware constituting a 3D-CAD apparatus or the method used to form a 3D model.

(Magnification and the size of attribution information)

25   The size of attribution information (the height of a character or a symbol) correlated with an attribution allocation plane is changed in accordance

with the magnification used for the attribution allocation plane (Fig. 23B).

The size (mm) of the attribution information is defined as the size in the virtual three-dimensional

5   space wherein the 3D model is present (not the size when the attribution information is displayed on the display device 204).

Assume that the size of the attribution information is 3 mm for the attribution allocation

10   plane 211 (magnification of 1). Fig. 23C is a diagram showing an example wherein the attribution information is also displayed with the character height of 3 mm for the attribution allocation plane 217 (a magnification of 5).

15   Since the attribution information correlated with the attribution allocation plane 217 is displayed at a magnification of "5", the size of the attribution information is 15 mm.

The square lines in Figs. 23B and 23C indicate

20   available display range for the display device 204.

When the attribution information sets are arranged so they are not overlapped, the position of the 3D model 1 is separated from that of the attribution information, so that the geometry of the

25   3D model 1 and the correlation with the attribution information are not easily understood, and an erroneous reading may occur. Further, when there are

many attribution information sets to be displayed, all the attribution information sets can not be displayed on the display device 204, and extra labor for changing the display range is required in order

5 for the attribution information to be seen outside the display available range.

If the size of a character is not changed for the display of a reduced size (magnification of less than "1"), the display area of the attribution

10 information on the display device 204 becomes smaller while the image at the reduced size is displayed. As a result, the contents of the attribution information can not be read.

Therefore, it is preferable that, while taking

15 into account the time that the attribution information is to be displayed, the size of the attribution information be changed in accordance with the magnification.

Thus, the magnification should be approximately

20 inversely proportional to the size of the attribution. As an example, when the magnification of the attribution allocation plane 211 is "1" and the size of the attribution information is 3 mm, the size of the attribution information correlated with the

25 attribution allocation plane 217 is set to 0.6 mm.

(Selection of a plurality of attribution allocation planes)

In this embodiment, to display attribution information correlated with an attribution allocation plane, only one attribution allocation plane is selected. An explanation will now be given for a case where a plurality of attribution allocation planes are selected.

Since there is only one visual position and one visual direction when a single attribution allocation plane is selected, only one display method is employed for the display device. When a plurality of attribution allocation planes are selected, a plurality of display methods must be employed, so that some display means is required. For example, all the attribution information correlated with a plurality of selected attribution allocation planes may be displayed, and the setting for a specific attribution allocation plane can be selected and used for the visual position and the visual direction.

Further, the attribution information can be displayed by using a different color for each correlation attribution allocation plane, so that different attribution information groups can be easily identified.

(Horizontal or vertical setting of an attribution allocation plane)

Thus far, only the setting of the visual position, the visual direction and the magnification

according to the present invention has been explained, and no explanation has been given for the horizontal or vertical setting of the attribution allocation plane.

5   In the two-dimensional drawing, rules are provided for the allocation of views (a plan view, a front view and a side view) obtained in the individual visual directions in Fig. 25. This is because the positional relationship viewed in each

10   visual direction must be easily understood in order to represent the actual three-dimensional geometry on a two-dimensional plane.

For the 3D drawing, whereat the attribution information is added to the 3D model, it is possible

15   to provide not only the two-dimensional representations (Figs. 9, 10B and 11B) viewed in the direction perpendicular to the external face of the 3D model, but also the three-dimensional representations (Figs. 10A and 11A) that are viewed

20   in the oblique direction by rotating the 3D model in the two-dimensional state.

Therefore, in the three-dimensional representation, the horizonal or vertical direction (it is assumed that the horizontal and vertical

25   directions match the corresponding directions on the display screen) of the attribution allocation plane need not be specifically defined in order to display

the plan view, the front view and the side view. So
long as the 3D model and the attribution information
attached thereto are correctly expressed, all the
representations in Figs. 29A to 29E can be correct

5   representations. Further, when the 3D model is
rotated slightly, the 3D model can be displayed
three-dimensionally, and it is easy to identify in
what part of the 3D model the currently displayed
portion is located, and to easily understand the plan

10   view and the side view taken in another visual
direction. Thus, no special problem is encountered
when the 3D model is displayed in the horizontal or
vertical direction of the attribution allocation
plane without taking into account the positional

15   relationship of the visual directions.

However, in the three-dimensional drawing
wherein attribution information is added to the 3D
model, not all the operator conditions can be such
that the operators can be freely rotated to display a

20   3D model. This is because there are some offices that
do not require that a 3D drawing be corrected, and
that need only store and read, as digital data, the
two-dimensional image data displayed on each
attribution allocation plane. Furthermore, there are

25   also offices that can cope with only conventional
paper drawings.

On this assumption, a rule used for the two-

dimensional drawing must be employed for the display
viewed in each visual direction.

Thus, before generating the attribution
allocation plane, the horizontal or vertical
5   direction for the display of the 3D model on the
display device 204 must be set.

Fig. 30 is a flowchart for this process.

First, a 3D model is created (step S3001).

Then, the visual position, the visual direction
10   and the magnification for the 3D model are set, and
the attribution allocation plane is generated (step
S3002).

The horizontal direction (or the vertical
direction) of the attribution allocation plane is
15   designated (step S3003). For this designation, the
three axial directions (X, Y and Z) present in the
(virtual) three-dimensional space may be selected, or
the direction of the ridge line of the 3D model or
the vertical direction of the plane of the 3D model
20   may be selected.

When the horizontal direction (or the vertical
direction) of the attribution allocation plane is
designated, the positions whereat the 3D model and
the attribution information are displayed are
25   determined by selecting the attribution allocation
plane.

To create another attribution allocation plane,

the horizontal direction (or the vertical direction)
need only be designated while maintaining the visual
direction of the created attribution allocation plane.

(Method for displaying attribution information)

5   In the explanation given for the embodiment, as
a method for selectively displaying attribution
information entered for the 3D model, first, an
attribution allocation plane is selected, and then,
attribution information correlated with the

10   attribution allocation plane is displayed as needed.
The embodiment is not limited to this method, however.
As another effective method, attribution information
is selected, and the 3D model and the attribution
information are displayed at the visual position, in

15   the visual direction and at the magnification for the
attribution allocation plane correlated with the
attribution information.

Fig. 31 is a flowchart showing the processing
sequence for the selection and display of attribution

20   information.

When the 3D model and the attribution
information in the plan view in Fig. 8 are displayed,
a cylindrical projection $\phi 12\pm0.2$ is selected (step
S311).

25   The 3D model and the attribution information
correlated with the attribution allocation plane 211
are displayed based on the visual position, the

visual direction and the magnification that are set for the attribution allocation plane 211 (step S312). In this case, the front view in Fig. 9 is positively displayed.

5   Therefore, since the relationship of the selected attribution information and the 3D model is displayed two-dimensionally, the relationship can be easily identified.

(Plane selection method)

10   In this embodiment, as a method for selectively displaying attribution information entered for the 3D model, first, an attribution allocation plane or attribution information is selected, and then, the attribution information correlated with the

15 attribution allocation plane is displayed as needed, based on the setting for the attribute allocation plane. The embodiment is not limited to this method, however. As another effective method, the geometric information (Geometry) for the 3D model is selected,

20 the attribution information correlated with the geometric information is displayed, and the 3D model and the attribution information are displayed at the visual position, in the visual direction and at the magnification for the attribution allocation plane

25 correlated with the attribution information.

Fig. 32 is a flowchart showing the processing sequence for the selection and the display of

attribution information.

Geometric information (ridge lines, planes and vertexes) for the 3D model is selected (step S321).

Attribution information correlated with the
5   selected geometric information is then displayed (step S322).

When there are a plurality of correlated attribution information sets, all of them may be displayed. Further, all the attribution information
10   belonging to attribution information planes with which attribution information is correlated may be displayed.

Next, the 3D model and the attribution information are displayed based on the visual
15   position, the visual direction and the magnification (the horizontal direction of the attribution allocation plane) of the attribution allocation plane correlated with the displayed attribution information. At this time, when a plurality of attribution
20   allocation planes are to be selected, the operator is permitted to select the planes that are to be displayed.

Since correlated attribution information can be searched for and displayed using the geometry of the
25   3D model as a key, this is a very practical method.

* Selection of geometric information → display of correlated attribution information (single set) →

display of attribution information at a position on a correlated attribution allocation plane.

* Selection of geometric information → display of correlated attribution information (single set).

5 Display all the attribution information correlated with an attribution allocation plane.

* Selection of geometric information → display of correlated attribution information (multiple sets) → display of attribution information sets at

10 positions on a single correlated attribution allocation plane.

* Selection of geometric information → display of correlated attribution information (multiple sets). Display all the attribution information sets

15 correlated with attribution allocation planes.

* Selection of geometric information → display of correlated attribution information (multiple sets) → display of attribution information sets at positions on multiple correlated attribution

20 allocation planes.

* Selection of geometric information → display of correlated attribution information (multiple sets). Display all the attribution information sets correlated with attribution allocation planes.

25 (Display and use)

An explanation will now be given for the processing for displaying and employing a 3D model to

which the thus generated attribution information is added.

Data for a 3D model, to which the attribution information prepared by the information processing
5   apparatus in Fig. 1 is added, can be transmitted by the information processing apparatus directly or via an external connecting device, and can be displayed by another information processing apparatus, as in Fig. 2, at the steps in Fig. 1.

10   First, an operator, a design engineer who designs products/units/parts, positively displays a generated 3D model in the manner shown in Figs. 9, 10B and 11B, so that new attribution information can be added to a 3D model as though a two-dimensional
15   drawing was being prepared. For example, when the shape of a 3D model is complicated, as needed, the three-dimensional representation and the two-dimensional representation for the 3D model are alternately displayed, or are displayed on the same
20   plane. Thus, desired attribution information can be entered efficiently and accurately.

Further, an operator who is to examine/approve the generated 3D model displays and examines it by displaying the representations of the 3D model shown
25   in Figs. 9, 10B and 11B on the same plane or alternately. Then, marks or symbols indicating "inspected", "OK", "NG", "suspended" and "re-

examination required", or attribution information,

such as coloring, are added. In this case, it is

natural for the operator to examine the 3D model by,

as needed, comparing it with or referring to a

5 plurality of products/units/parts.

Furthermore, a design engineer or a designer

other than the creator of a 3D model may refer to the

generated 3D model to design another

product/unit/part. By referring to the 3D model, it

10 is easy to apprehend the intent of the creator or the

design method.

Further, when preparing a 3D model for use in

manufacturing, an operator can add to it required

information or attribution information. In this case,

15 the operator is an engineer tasked with setting up

the processing for the manufacture of

products/units/parts. The operator instructs the use

of a process type and tools, or adds corners R or the

chamfering of ridge lines, angular portions or

20 corners that is required for the machining of the 3D

model. Either this, or the operator instructs a

measurement method to be used for a dimension or a

dimensional tolerance, adds measurement points to a

3D model, or enters measurement notes. The operator

25 can efficiently perform this operation by referring

to the representations shown in Figs. 10B and 11B,

which are easy to apprehend visually, and by, as

needed, confirming the geometry three-dimensionally.

An operator can obtain information required for a desired preparation from the 3D model or the attribution information. In this case, the operator

5 is a design engineer tasked with designing metal molds, tools and various types of devices required for manufacturing the 3D model. The operator apprehends the shape of the 3D model by referring to its representation in three-dimensional space, and

10 extracts required information, which is easily perceived visually, from the representations shown in Figs. 9, 10B and 11B. Then, based on the attribution information, the operator designs metal molds, tools and devices. When, for example, the operator is a

15 metal mold designer, based on the 3D model and the attribution information, the operator designs metal molds by examining their structure, and adds, as needed, the corners R and the chamfering to ridge lines, angular portions and corners that are required

20 for the manufacture of metal molds. Further, when a metal mold is a resin injection molded type, the operator adds a draft angle required for the molding of the 3D model.

Furthermore, an operator who is responsible for

25 the manufacture of products/units/parts can also employ this embodiment. In this case, the operator will be a product/unit/part machining or assembly

engineer. While referring to the representations in Figs. 9, 10B and 11B, which are easily apprehended visually, and, as needed, confirming the shape three-dimensionally, the operator efficiently and

5   accurately obtains the measurement method used for dimensions or dimension tolerances, the measurement points and the notes provided for the measurements and begins to perform the inspection, measurement and evaluation operation. Then, again as needed, the

10 operator can add to the 3D model, as attribution information, the inspection, measurement and evaluation results that are thus provided. The operation can provide, for example, measurement results corresponding to the dimensions. In addition,

15 the operator enters marks or symbols for the attribution information or for portions of the 3D model for which the dimensional tolerances are exceeded, or to indicate defects, such as scratches. Further, in addition to the examination results,

20 marks or symbols indicting "inspected", "measured" and "evaluated" or coloring may be provided.

Moreover, an operator who works for a department, or is responsible for the manufacture of products/units/parts can employ this embodiment. In

25 this case, the operator is a person tasked with analyzing manufacturing costs, a person responsible for the ordering of products/units/parts or various

associated parts, or a person charged with overseeing the creation of operation manuals or the preparation of packing materials for products/units/parts. In this case, also while referring to the 3D model three

5 dimensionally, the operator can easily apprehend the shape of a product/unit/part, and can efficiently perform his or her job by referring to the representations in Figs. 9, 10B and 11B, which are easily perceived visually.

10 Input an inspection instruction

An inspection instruction will now be described.

As is described above, in order to inspect a produced metal mold or part, a 3D model is displayed for which dimensions have previously been allocated.

15 During this processing, attribution information is entered for an attribution allocation plane that was previously designated so that a position to be inspected is clearly displayed.

Specifically, a 3D model is formed, and the

20 sequential inspection order, the positions to be inspected and the inspection entries for planes, lines and ridge lines are input. By conducting the inspection in the order designated, the number of inspection steps is reduced.

25 First, the entries and positions to be inspected are entered and the overall display is presented. Then, using a predetermined method, the inspection

order is assigned for the individual entries. For an actual inspection, an attribution allocation plane is selected by designating the inspection order, and on the attribution allocation plane, in order to clearly

5 identify the inspection positions, faces at the positions to be inspected are displayed in different forms (different colors).

Then, the inspection results provided and whether re-molding is required are input for the

10 individual designated inspection entries.

As is described above, according to the embodiment, an easy to see screen can be obtained by performing a simple operation for which attribution allocation planes and attribution information are

15 used. Further, the relationship between the visual direction and the attribution information can also be perceived at a glance. Furthermore, since dimensional values are input in advance, erroneous readings, the result of operator manipulation errors, can be

20 reduced.

In addition, since only information correlated with the visual direction can be read, required information can be easily obtained.

Moreover, since a large amount of attribution

25 information in the same visual direction is allocated to a plurality of attribution allocation planes, an easy to see screen can be presented, and required

information can be easily obtained.

Also, since an attribution allocation plane is set inside the 3D model, i.e., in its cross section, correlated attribution information can be displayed
5   so that it is easily understood.

Since the size of attribution information is changed in accordance with the display magnification for the attribution allocation plane, the attribution information can be appropriately represented so it
10 can be identified easily.

Further, since the attribution information is provided on the attribution allocation plane, it can be read even from a three-dimensional oblique view of the 3D model.

15 Furthermore, since by using the attribution information as a key the attribution allocation plane can be searched and only information correlated with the attribution allocation plane can be read, required information can be easily obtained.

20 And in addition, since by using the geometric information as a key the attribution information and the attribution allocation plane can be searched for and only information correlated with the attribution allocation information can be read, required
25 information can be easily obtained.

(View)

Fig. 33 is a diagram showing the state wherein a

dimension a, which is attribution information, is correlated with a view.

As is shown in Fig. 33, the attribution information is positioned in the visual direction of 5 the view (the perpendicular direction from the surface side of the paper to the face of the paper).

As well as the attribution allocation plane, the view is defined by the visual direction, the visual position and the magnification, and is correlated 10 with the attribution information. However, unlike the attribution allocation plane, the attribution information is not located on the same plane as the view.

Similarly, Figs. 34A and 34B are diagrams 15 showing the state wherein a dimension b, which is attribution information, is correlated with the attribution allocation plane. The plane in Fig. 34B is the one viewed in the visual direction indicated by an arrow A in Fig. 34A. As is shown in Figs. 34A 20 and 34B, the dimension b, which is the attribution information, is positioned in the normal direction indicated by the arrow A of the attribution allocation plane.

Figs. 35A and 35B are diagrams showing the state 25 wherein the attribution information correlated with the views are displayed. When one view is selected, a list 501, including attribution information sets 502

to 505 correlated with the selected view, is
displayed. When a view is selected in accordance with
a view selection command, all the attribution
information sets 502 to 505 correlated with the

5   selected view are highlighted (Fig. 35A). When a
pointer 506 is provided for each attribution
information set on the list 501, only the attribution
information 503 is highlighted (Fig. 35B). The
current state on the screen may be either the state

10   of a view to which the attribution information sets
502 to 505 are correlated, or the state of another
view.

        Figs. 36A and 36B are diagrams showing the state
wherein attribution information correlated with an

15   attribution allocation plane is displayed. In Fig.
36A, when a list of attribution allocation planes is
displayed in accordance with an attribution
allocation plane selection command, and when one
attribution allocation plane 511 is selected on the

20   list, a list 512 of attribution information sets
correlated with the attribution allocation plane 511
is displayed. When the attribution allocation plane
511 is selected, the list 512 is displayed, and at
the same time, all the attribution information sets

25   related to the attribution information sets 507 to
510 and the frame of the attribution allocation plane
511 are highlighted. In Fig. 36B, when a pointer 513

is moved to the name of the attribution information
508 on the list 512, only the attribution information
508 is highlighted on the screen.

Fig. 37 is a flowchart showing the processing
5   for generating attribution information and
correlating it with a view. First, a view is created
(step S401) and the direction and the position of the
view are stored in the storage means (step S402).
Then, attribution information is generated (step
10   S403) and is correlated with the view (step S404).
The direction of the attribution information is
arranged at the position of the correlated view (step
S405). The pair consisting of the attribution and the
correlation view, and the direction of the
15   attribution information are stored in the storage
means, and are displayed (step S406).

Once the view attribution information is to be
correlated with is set, all the attribution
information that is generated is correlated with the
20   pertinent view, until the setting is changed.

One attribution information set need not be
correlated with only one view, and can be correlated
with a plurality of views and displayed (Fig. 44).

Further, the attribution information need not
25   only be correlated with a view currently displayed on
the screen, but also with another desired view. In
Fig. 45, for example, a view 531 is currently

displayed; however, on this screen, attribution information can be correlated with a view 523.

Fig. 38 is a flowchart showing the processing for generating attribution information, for

5   maintaining the free state of the attribution information instead of correlating it with a view, and for, at any time later, correlating the attribution information with a desired view. First, attribution information is created (step S411), and

10   in the process for determining a view with which the attribution information is to be correlated, the free state is selected (step S412). When another operation has been performed and a specific time has elapsed, a view selection command is selected in order to

15   correlate the generated attribution information with a desired view (step S413). A list of views is displayed when an attribution information correlation command is selected from among view selection commands included in an attribution information

20   command, and a desired view with which attribution information is to be correlated is selected (step S414). The correlation of the attribution information and the view is stored in the storage means and is displayed (step S415).

25   In this case, the attribution information in the free state is always temporarily stored in correlation with the dedicated attribution allocation

plane for the free attribution information. It should be noted that when the free attribution information has been correlated with the dedicated attribution allocation plane for the free attribution information

5 a warning is displayed as needed to request correlation with a desired attribution allocation plane.

When a warning command is selected in advance, each time the storage of attribution information in

10 the free state is instructed a function is executed for displaying a warning indicating that free attribution information is present. If the warning command is not selected, the warning is not displayed and the attribution information in the free state is

15 permanently correlated with the dedicated attribution allocation plane for the free attribution information. So long as the attribution information is temporarily correlated with the dedicated attribution allocation plane for the free attribution information, even when

20 the most suitable attribution allocation plane for the attribution information to be correlated with is not visually identified during the attribution information generation process, an attribution allocation plane that is visually most suitable can

25 be selected after the entire arrangement (the positioning of the 3D model and the attribution allocation plane) is determined.

Fig. 39 and Figs. 41A to 41F are respectively a flowchart and diagrams showing the processing for changing a view correlated with attribution information into another view. First, a view

5 selection command included in an attribution information command is selected (step S421). A view list 520 and arrows b indicating the names of all the visual directions are displayed on the screen (Fig. 41A). At this time, when a pointer 522 is moved to

10 one of view names 523 to 532 in the list 520 on the screen or to the arrow b indicating the visual direction of the view 523, the attribution information 533 to 542 correlated with the view 523 that is pointed to, and the arrow b corresponding to

15 the view 523 are highlighted (step S422) (Figs. 41B and 41C). Then, the view 523 is selected (step S423). At this time, the view 523 may be selected using the list 520, or it be selected using the arrow b (Figs. 41B and 41C). When a list 543 of attribution

20 information sets 533 to 542 correlated with the selected view 523 is displayed on the screen, and when the pointer 522 is moved to attribution information 534 on the list 543, the attribution information 534 is highlighted on the screen (step

25 S424) (Fig. 41D). During the process for selecting the attribution information 534 for which a correlated view is to be changed, a plurality of

attribution information sets may be selected (step S425). The view list 520 and the arrow b indicating the visual direction of a view are displayed on the screen (step S426). At this time, when the pointer

5   522 is moved to one of the view names 523 to 532 on the list 520 or an arrow b 527 indicating the visual direction, the attribution information sets 544 to 546 correlated with the view 527 are highlighted (Fig. 41E). When the pointer 522 is moved away from the

10 view name or the arrow, the pertinent view name or arrow is not displayed. One view with which the attribution information 534 is to be correlated is selected from the list 520 or by using the arrow b indicating the visual direction with the view name

15 (step 427). During this selection process, a plurality of views may be selected, and the attribution information may at one time be correlated with these views. The arrow b 527, which indicates the visual direction of the newly correlated view,

20 and the attribution information 534, for which the correlated view is changed, are highlighted (step S428). When a plurality of attribution views are used for correlation, all the arrows in the visual directions of the correlated views are displayed.

25 Then, in the Yes/No selection, Yes is selected and established (step S429) (Figs. 41A to 41F).

The means indicating the visual direction of the

view is not limited to the arrows shown in Figs. 41A
to 41F and figs. 42A to 42D. So long as the visual
direction of the view is displayed so it is easily
understood, a leader line may be extended to near the
5   model to represent the visual direction of the view
near the model, or another means may be employed.

Fig. 40 and Figs. 42A to 42D are respectively a
flowchart and diagrams showing the processing, for
another method for changing a correlated view, for
10   correlating attribution information in the free state
with a desired view. The attribution information 547
for which a view correlated on the screen is to be
changed, or the attribution information 547 in the
free state is selected (step S431) (Fig. 41A). When
15   the change of a view is selected from a menu 548
(step S432), a view list 549 and arrows c indicating
the visual directions of all the views are displayed.
At this time, when a pointer 566 is moved to one view
558 on the list 549, or to the arrow c indicating a
20   visual direction 558, all the attribution information
sets 561 to 565 correlated with the view 558 are
highlighted (step S433) (Figs. 41B and 41C). One view
558 is selected from the list 549 or by designating
one arrow c (step S434) (Figs. 41B and 41C). In this
25   selection process, a plurality of views 551 to 560
may be selected and the attribution information 547
can at one time be correlated with these views.

Further, the arrow c indicating the visual direction
of the view 558 that is newly correlated, and the
attribution information 547 for which the view has
been changed are highlighted (step S435). When a
5   plurality of views to be correlated are employed,
arrows indicating all the correlated views are
highlighted. Then, in the Yes/No selection, Yes is
selected and established (step S436) (Fig. 41D).

In this case, the attribution information in the
10 free state is always temporarily stored in
correlation with a dedicated view for free
attribution information. It should be noted that when
the free attribution information has been correlated
with the dedicated view for the free attribution
15 information a warning is displayed as needed to
request correlation with a desired view.

When a warning command is selected in advance,
each time the storage of attribution information in
the free state is instructed, a function for
20 displaying a warning indicating that free attribution
information is present is executed. If the warning
command is not selected, the warning is not displayed
and the attribution information in the free state is
permanently correlated with the dedicated view for
25 the free attribution information. So long as the
attribution information is temporarily correlated
with the dedicated view for the free attribution

information, even when the most suitable view for attribution information to be correlated with is not visually identified during the attribution information generation process, a view visually most

5 suitable can be selected after the entire arrangement (the positioning of the 3D model and the view) has been determined.

Fig. 43 is a flowchart showing the processing performed when attribution information correlated

10 with a specific attribution allocation plane is to be correlated with other multiple attribution allocation planes, and when attribution information in the free state is to be correlated with a desired attribution allocation plane. First, attribution information is

15 selected (step S441), a list of attribution allocation planes is displayed (step S442), and an attribution allocation plane is selected from the list (step S443). At this time, when a pointer is moved to one of the attribution allocation planes on

20 the list, so long as the allocation attribution plane is set in the display state, the designated attribution allocation plane and all the attribution information correlated therewith are highlighted. When the pointer is removed, the highlight indication

25 is canceled. When the attribution allocation plane is set in a non-displayed state, and when the pointer is moved to one of the attribution allocation planes on

the list, the designated attribution allocation plane
and the attribution information correlated therewith
are highlighted. When the pointer is removed, the
attribution allocation information and the

5   attribution information are not displayed. During
this selection process a plurality of attribution
allocation planes may be selected, and attribution
information may at one time be correlated with these
attribution allocation planes. Finally, while all the

10   selected attribution allocation planes and the
correlated attribution information have been
highlighted, Yes is selected, and the correlation
process is terminated (step S444).

Fig. 46 is a flowchart showing the processing

15   for generating attribution information and for
correlating it with the attribution allocation plane.
First, the attribution allocation plane is created
(step S451), and the normal direction of the
attribution allocation plane and its position are

20   stored in the storage means (step S452). Then, the
attribution information is prepared (step S453) and
is correlated with the attribution allocation plane
(step S454). The direction of the attribution
information is determined to be on the correlated

25   attribution allocation plane (step S455). The
attribution information and the correlation
attribution allocation plane, and the direction of

the attribution information are stored in the storage means and are displayed (step S456).

Once the attribution allocation plane to be correlated is set, all the attribution information that is prepared can be correlated with the attribution allocation plane until the setting is changed.

The attribution information may not always be correlated with only one attribution allocation plane, but may also be correlated with a plurality of attribution allocation planes, and the attribution information and these planes can be stored and displayed (Fig. 47).

Furthermore, the attribution information can be correlated not only with an attribution allocation plane that is currently displayed, but also with a desired attribution allocation plane. For example, in Fig. 48, an attribution allocation plane 550 is currently displayed; however, regardless of the plane on the screen, attribution information 553 can be correlated with desired attribution allocation planes 550 to 552.

Fig. 49 is a flowchart showing the processing for generating attribution information, for maintaining the free state of the attribution information instead of immediately correlating it with an attribution allocation plane, and for, at any

time later, correlating the attribution information
with a desired view. First, attribution information
is created (step S461), and in the process for
determining an attribution allocation plane with
5   which the attribution information is to be correlated,
the free state is selected (step S462). When another
operation has been performed and a specific time has
elapsed, a view selection command is selected in
order to correlate the above generated attribution
10   information with a desired attribution allocation
plane (step S463). A list of attribution allocation
planes is displayed when an attribution information
correlation command and a desired attribution
allocation plane with which attribution information
15   is to be correlated are selected (step S464). At this
time, a plurality of attribution allocation planes
may be selected. The correlation of the attribution
information and the attribution allocation plane is
stored in the storage means and is displayed (step
20   S465).

Fig. 50 and Figs. 51A to 51E are respectively a
flowchart and diagrams showing the processing for
changing an attribution allocation plane correlated
with attribution information to another attribution
25   allocation plane. First, an attribution allocation
selection command included in an attribution
information command is selected (step S471). A view

list 558 of attribution allocation planes and all the
generated attribution allocation planes 554 to 556
are highlighted on the screen (Fig. 51A). At this
time, when a pointer 557 is moved to the attribution

5   allocation plane 554 on the list 558 on the screen,
the attribution allocation plane 554 and the
attribution information 559 to 562 correlated
therewith are highlighted (step S472) (Fig. 51B).
Then, the attribution allocation plane 554 is

10   selected (step S473). When the pointer 557 is moved
to the attribution information 559 on the list 565,
only the attribution information 559 is highlighted
on the screen (step S474) (Fig. 51C). Further, the
selected attribution allocation plane 554 is

15   maintained in the highlighted state. The attribution
information 559 is selected for which the correlated
attribution allocation plane is to be changed (step
S475), and the list 558 of the attribution allocation
planes is displayed on the screen (step S476). Also

20   at this time, when the pointer 557 is moved to the
attribution allocation plane 555 on the list 558, the
attribution allocation plane 555 and the attribution
information sets 563 and 564 correlated therewith are
highlighted on the screen. When the pointer 557 is

25   moved away, the image is set in the non-displayed
state (Fig. 51D). The attribution allocation plane
555 with which the attribution information is to be

correlated is then selected from the list 558 (step S477). At this time, a plurality of attribution allocation planes 554 to 556 may be selected. Then, the attribution information 559 for which the

5 correlated attribution allocation plane is changed is highlighted (step S478). Then, in the Yes/No selection, Yes is selected and established (step S479) (Fig. 51E).

Fig. 52 is a diagram showing a menu to be

10 displayed when automation is selected. For the automation of the correlation of attribution information, the column "the view on current display" is included in the columns provided for the selection of a view to be correlated. Once that column is

15 selected and the direction of the view displayed on the screen is changed, a new view is generated in the new direction on the screen and the attribution information that is thereafter generated, changed or added is correlated with the new view. Further, as a

20 view is being generated, the number of views available for selection using the column is increased.

With this function, since correlation with the view is not required each time attribution information is generated, the period required for the

25 creation of a drawing can be reduced.

Fig. 53 is a diagram showing a menu to be displayed when automation is selected. For the

automation of the correlation of attribution
information, the column "the attribution allocation
plane on current activation" is included in the
columns provided for the selection of attribution

5   allocation plane to be correlated. Once that column
is selected, regardless of the screen display, the
attribution information that is thereafter generated,
changed or added is correlated with the attribution
allocation plane that is active when the attribution

10   information is generated. Further, as a view is being
generated, the number of views available for
selection using the column is increased.

With this function, since correlation with the
attribution allocation plane is not required each

15   time attribution information is generated, the period
required for the creation of a drawing can be reduced.

An explanation will now be given for another
embodiment for the correlation of attribution
information in the free state.

20   When attribution information in the free state
is present, by merely monitoring all the attribution
allocation planes or views, this information is
possibly missed. Therefore, free attribution
information must be searched for, and this greatly

25   deteriorates the efficiency attained for each job. To
avoid this problem, it is preferable that, as in the
invention, all the attribution information be

correlated with a desired attribution allocation plane or view. The correlation process is not limited to the method described in the embodiment, and the following method may also be employed.

5   This method prevents the production of drawings while there is any free attribution information remaining. During the processing, when attribution information is generated, an allocation attribution plane to be used for correlation is immediately

10   selected. With this arrangement, if the attribution allocation plane to be correlated with the attribution information is not determined, the generation of attribution information can not be continued.

15   An explanation will now be given for the embodiment for the correlation of free attribution information.

In this embodiment, it is assumed that a dedicated attribution allocation plane for free

20   attribution information is not present.

That is, in this embodiment, the temporary presence of attribution information in the free state is permitted.

If a correlated attribution allocation plane is

25   not selected while attribution information is being generated, a warning is issued, and the generated attribution information is stored as free information

that is not correlated with any attribution

allocation plane. Unlike the previous embodiment, the

free attribution information is not stored in

correlation with a dedicated attribution allocation

5   plane for the free attribution information, but

instead is stored as separate attribution information.

However, while the free attribution information

can be stored during the generation process, a

warning is issued each time. And even when a user

10   ascertains that the preparation of drawings has been

completed and prepares to store them, the drawings

can not be stored as a complete set because the

system includes means for finding free attribution

information that has not been correlated with an

15   attribution allocation plane and for designating such

drawings as incomplete. Further, the system includes

means for refusing to progress to the next step

(processing and confirming the drawings). Therefore,

in order to complete the drawings, all the free

20   attribution information must be correlated with the

attribution allocation plane correlated with the

model.

The above described arrangement can be also

employed for the view.

25   As is described above, when the attribution

information is entered or is read, the view or the

attribution allocation plane is positioned on the

screen as needed, and the 3D model and the attribution allocation information are arranged and displayed on the screen. That information can be transmitted efficiently to be easily understood.

5   (Another embodiment)

The scope of the present invention also includes a configuration wherein, to achieve the functions of the embodiment, software program code that implements the functions of the embodiment is supplied to an

10   apparatus or a system computer that is connected to various devices, and the devices are operated in accordance with a program stored in the computer (a CPU or an MPU) of the system or the apparatus.

In this case, invention functions are provided

15   by the software program code, and the program code also constitutes the present invention. The storage medium for supplying the program code can be a communication medium for a computer network (LAN or the Internet) system that acts as a carrier for the

20   transmission of program information.

Further, means for supplying the program code to a computer, e.g., a storage medium on which the program code is stored (a floppy disk, a CD-ROM, a magnetic tape, a nonvolatile memory card, a ROM, a

25   hard disk, an optical disk, a magneto-optical disk, etc.), constitutes the present invention.

In addition, with the present invention it is

not only possible for the functions of the previous

embodiment to be provided through the execution of

program code by a computer, but also, the program

code can interact with an OS (Operating System) or

5   with another software application running on the

computer to provide the functions described in the

above embodiment.

As many apparently widely different embodiments

for the present invention can be devised without

10   departing from the spirit and scope thereof, it is to

be understood that the invention is not limited to

the specific embodiments presented herein except as

defined in the appended claims.